START

DON'T SAY IT --- *Write It!*

DATE: February 8, 1993

TO: Cathy Massimino EPA
Dan Duncan EPA

FROM: Cliff Clark RL
Telephone: 509/376-9333

cc: R. C. Bowman WHC
D. L. Flyckt WHC
S. M. Price WHC
D. E. Scully WHC

bcc: J. L. Fields WHC
S. J. Skurla WHC

SUBJECT: RD&D PERMIT FOR HANFORD WASTE WATER TREATMENT LABORATORY: RESPONSES TO QUESTIONS POSED DURING 1/28/93 TELECON BETWEEN EPA REGION X AND WHC.

REF: 1. RL's "COMMENTS ON THE JOINT PERMIT FOR DANGEROUS WASTE RESEARCH, DEVELOPMENT, AND DEMONSTRATION TREATMENT AND STORAGE ACTIVITY (11/30/92 DRAFT)" COLLECTED BY STEVE SKURLA, WHC.

2. DOE/RL-91-39, REV.1, "WASTE WATER PILOT PLANT RESEARCH, DEVELOPMENT, AND DEMONSTRATION PERMIT APPLICATION," APRIL 1992.

This memo responds to questions on comments 22, 49, and 58 of reference 1 above.

Comment 22:

In figure 4-13 of reference 2, "Polymeric Backwashable Ultrafiltration System at the Liquid effluent Retention Facility," LF-pump-1 is the high pressure feed pump that will have the high pressure shutdown interlock (pressure switch). LF-pump-2 is a backwash pump.

Comment 49:

The original pilot plant reverse osmosis (RO) system as purchased during the summer of 1991 from Applied Membranes, Inc., was a 4 stage, 5 gpm feed system. (See figure 4-6 of reference 2.) The recommendations of Applied Membranes, Inc., to use 4" diameter membranes were followed. This nominal 5 gpm configuration was WHC's originally intended configuration, and was specified in revision 1 of the RD&D permit application (ref 2).

In the summer of 1992, WHC received the first information on the ETF RO system configuration through the vendor, Zenon Environmental Systems Inc. This system is a 2 stage system utilizing 8" diameter modules. Since it is paramount that the pilot plant simulate the full scale ETF system as closely as possible, WHC had to drastically reconfigure the existing pilot plant equipment (including the purchase of new high pressure pumps, saltwater membranes, and flowmeters). Comparison of the ETF and reconfigured pilot plant RO systems is fully presented in Attachment 1.

The primary emphasis for simulation was a duplication of the following parameters:

- membrane type
- array configuration
- flow/membrane area ratios
- feed pressures

WHC was able to match all of these parameters exactly, using the new configuration shown in Attachment 1. However, it was necessary to increase the feed rate to 11.6 gpm. The only significant parameter that WHC was not able to duplicate was flow velocity. Those of the pilot plant will be about half of those achieved by the ETF. The only way this parameter could be duplicated would be to install smaller diameter membranes. This is not seen as a serious detriment. The results achieved at the pilot plant with actual feed will be conservative compared to those expected from the ETF.

<u>Comment 58:</u>

WHC suggests that the system for automatic shutoff of feedpumps as specified in Permit condition V.E. shall be checked monthly (when the RD&D Activity is in operation), or every 100 operating hours, whichever comes sooner.

Attachment 1

1.0 INTRODUCTION & BACKGROUND

1.1 Project C-018H

Project C-018H, "200 Area Effluent Treatment Facility," (ETF) will construct a waste water treatment facility in the 200E area for the purpose of treating dilute Hanford Site waste waters. The design-basis feed for this facility is the condensate from the 242-A Evaporator. This facility is scheduled to begin operation in late 1994, treating 242-A Evaporator process condensate.

1.2 Waste Water Treatment Laboratory

The Waste Water Treatment Laboratory (WWTL) is being constructed at the 1706-KE building in the 100N area. The initial purpose of this laboratory is to allow demonstration of the ETF process on a pilot plant scale using actual feed from the 242-A Evaporator.

1.3 Reverse Osmosis

Reverse osmosis (RO) is the ETF's primary method to remove dissolved solids from the waste water. Pilot scale RO equipment will be tested at the WWTL.

2.0 WWTL DESIGN BASIS

To accurately simulate the operation of the ETF reverse osmosis process on a 1/15 pilot scale, the equipment configuration and operating parameters must be duplicated as closely as possible.

2.1 ETF Reverse Osmosis Configuration and Operating Parameters

The ETF RO system is a two-stage system (i.e., the permeate from the first stage is treated in the second stage). The membranes in the ETF design are a combination of brackish water (high-flow, low-salt rejection) and saltwater (low-flow, high-salt rejection) thin film composite (TFC), spiral wound, modules manufactured by the Filmtec Corporation. The system is sized to treat a 171 gpm, 2730 ppm total dissolved solids (TDS) feed stream. The ETF RO system will have a one-third excess capacity above the 171 gpm design, to allow for continued operation during membrane cleaning and replacement. Salt rejection is expected to be approximately 99 percent. The system design accommodates the requirement to limit the production of secondary waste by achieving 90 percent water recovery. The following detailed description of the ETF RO system reflects 100 percent design, as of January 1993. The ETF RO system configuration is depicted in Figure 1.

The first stage has three arrays. The first array has six pressure vessels in parallel (four in use, two in standby). The retentate is the feed to the second array. The second array has three pressure vessels in parallel (two in use, one in standby). The retentate from the second array feeds the third array. The third array has three pressure vessels in parallel (two in use, one in standby). Each pressure vessel will hold six 8-inch diameter by 40-inch long brackish water membrane modules, stacked in series. Within any given pressure vessel, all membrane modules are stacked in series; the feed is passed sequentially from module to module; and the permeate from each module is combined. A portion of the third array retentate is bled off as the secondary waste for the overall RO system, while the remaining retentate is recycled back and fed to the second array. The permeate from the third array combined with the permeate from the first and second arrays make up the feed to the second stage. Each pressure vessel within the first stage has approximately 1,776 square feet of membrane surface.

The second stage is configured in two arrays. The first array has six pressure vessels in parallel (four in use, two in standby). The first array pressure vessels are arranged in pairs. For each pair, the combined retentate feeds a pressure vessel in the second array. Each of the pressure vessels in the second stage are equipped with four 8-inch diameter by 40-inch long salt water TFC membrane modules. The combined permeate from all the second stage pressure vessels is the final purified RO product and is fed to the ion exchange (IX) unit. The retentate from the second array of the second stage is recycled back and combined with the feed to the first stage. Each pressure vessel within the second stage has approximately 1,184 square feet of membrane surface.

The system is equipped with three high-pressure pumps, two for the first stage and one for the second stage. The first pump will generate a pressure of approximately 240 pounds per square inch gauge (psig) for the first array of the first stage. The second pump will provide a pressure boost of approximately 150 psi for the second array of the first stage. This higher pressure is needed to overcome the high osmotic pressure of the final retentate. The third pump will generate a pressure of approximately 405 psig for the second stage. This high pressure is required to overcome the increased pressure drop across the saltwater membranes of the second stage as a result of the high permeate flux. This RO system is designed to produce a 154 gpm, 24 ppm TDS product stream and a 17 gpm, 31,260 ppm TDS secondary waste stream from the 171 gpm, 2730 ppm TDS feed stream. The intent of this ETF RO system design is to produce a clean waste water product with a 90 percent water recovery and a 99 percent salt rejection.

2.2 WWTL Reverse Osmosis Configuration and Operating Parameters

Reverse osmosis systems can be directly scaled based on permeate flux and water recovery. The permeate flux, the quantity of water flowing through the membrane per square foot per day, is a function of membrane type, osmotic pressure of the salt solution, temperature of the salt solution, and pressure applied to the salt solution. The osmotic pressure is determined by the amount and types of salts in the aqueous solution. The water recovery (the percent of water fed to the system that is recovered as permeate) is a function of membrane type, membrane surface area, feed temperature, flow velocity, and net pressure (applied pressure minus osmotic pressure). The total membrane surface area required to achieve the desired permeate flux and water recovery is determined by the flow rate of the feed stream and is dependent on the feed solution, membrane type, applied pressure, and flow velocity. A pilot-scale RO unit can be configured to produce the same net results (permeate flux and water recoveries) of a full-scale system by matching the flow velocities and the ratios of the feed flow rates to membrane surface areas.

The WWTL pilot-scale RO unit will consist of two stages, as shown in Figure 2. The pilot-scale system design will use the same brand and type of brackish water and saltwater membrane modules as used in the ETF RO system. However, the pilot plant will use 4-inch diameter modules rather than the 8-inch diameter modules designated for the ETF. The first array will have two pressure vessels in parallel. Each pressure vessel will hold three 4-inch diameter by 40-inch long brackish water modules (within any given pressure vessel, all membrane are arranged in series). The retentate from the first array will feed the second array, which consists of one pressure vessel. Three 4-inch diameter by 40-inch long brackish water membrane modules will be used in this one pressure vessel. The second array retentate will feed the third array, which consists of one pressure vessel. Three 4-inch diameter by 40-inch long brackish water membrane modules will be used in this pressure vessel. A portion of the retentate from the third array will be the secondary waste for the overall RO system, while the remaining retentate is recycled back and fed to the second array. The permeate from the three arrays of the first stage are combined to make up the feed to the second stage. (Each pressure vessel in the first stage contains 240 square feet of membrane surface).

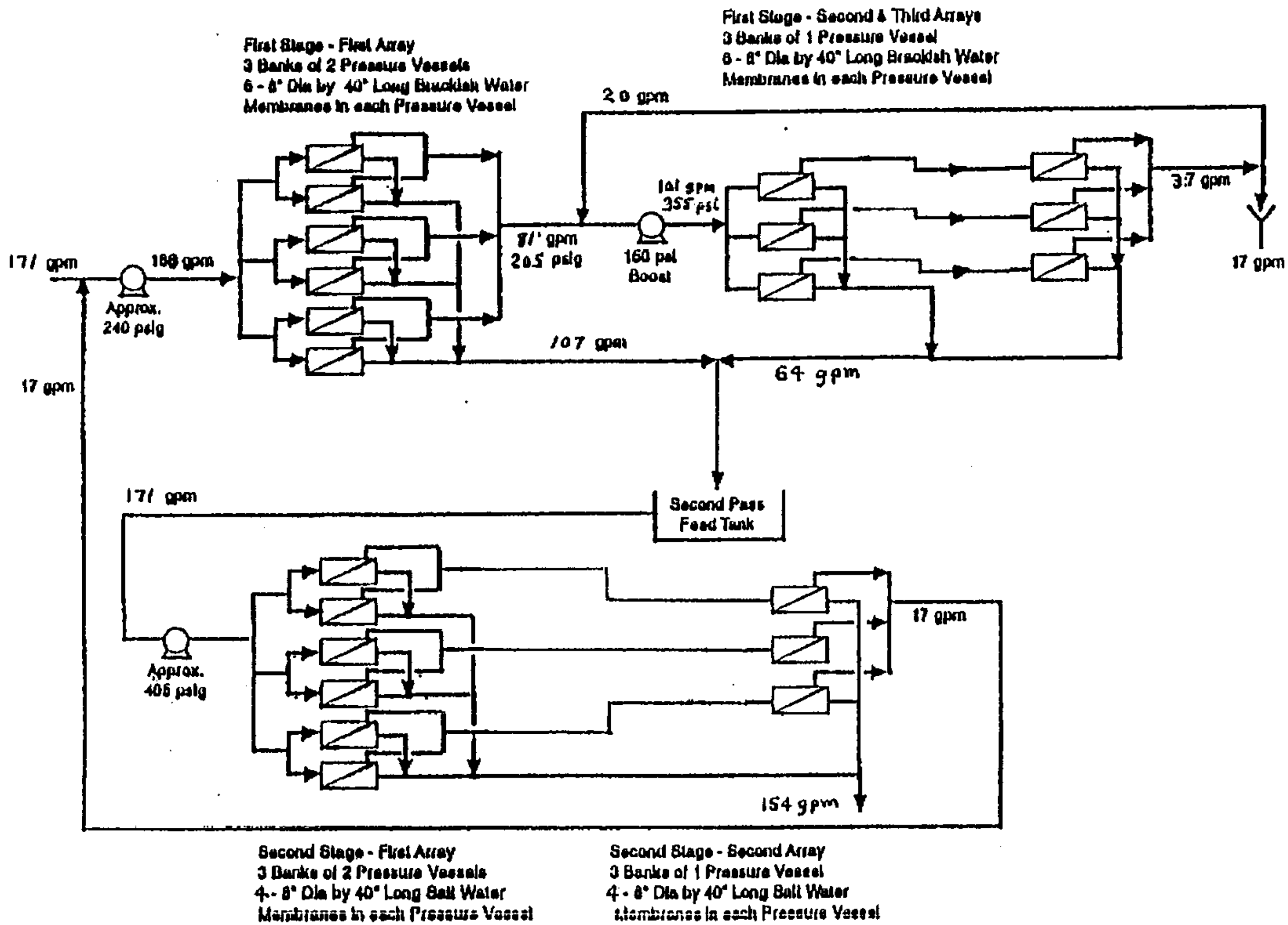
The second stage will be organized into two arrays. The first array will have two pressure vessels in parallel. Each pressure vessel will hold two 4-inch diameter by 40-inch long saltwater membrane modules. The retentate from the first array will feed the single pressure vessel of the second array. This single pressure vessel will hold two 4-inch diameter by 40-inch long saltwater membrane modules. The retentate is recycled back to the first stage. The second array permeate combined with the permeate from the first array will be the overall RO system purified product water. (Each pressure vessel in the second stage contains 160 square feet of membrane surface.)

The pilot RO design, corresponding to the full-scale ETF RO system, will convert an 11.6 gpm, 2730 ppm TDS feed stream into a 1.1 gpm, 31,260 ppm TDS retentate stream and a 10.5 gpm, 24 ppm permeate stream. The pilot-unit design uses three high pressure pumps. The first pump will pressurize the first stage feed to approximately 240 psig. The second pump will boost the feed to the second array of the first stage by approximately 150 psi. The third pump will pressurize the second stage feed to approximately 405 psig. The pressures stated above are based on ETF design conditions. Actual pressures in the pilot RO may vary due to the salt concentration of the actual feed. The pump arrangement and feed pressures correspond to the 100 percent design of the ETF RO system as of January 1993.

Stream flow rate (based on permeate flux--see Figure 3) will be the primary parameter for control throughout the RO system. Flows will be controlled using pressure reducing valves and flow meters. The RO unit's actual performance is a function of total dissolved solids and the matrix of salts in the feed solution. Therefore, pressures, flows, and salt rejection of the pilot unit are expected to vary somewhat from the ETF design conditions.

2.3 Comparison of ETF and WWTL Reverse Osmosis Parameters

The critical scale-up parameters for reverse osmosis (RO) are feed composition, membrane type, permeate flux, and inlet pressure. Pilot plant membrane types are the same as those for the ETF, and the array configurations are duplicated as much as possible within the limitations of the differences in module diameter (8" vs 4"). Permeate flux and inlet pressure are not independent variables and are affected by salt composition and concentration. For the pilot-plant RO system, permeate flux will be controlled to match those specified for the ETF. Pressure will be varied as required to maintain the desired permeate flux. **Ultimately however, the pilot unit using actual feed, will be tuned to achieve as close to 99% salt rejection as possible.** Although the array configurations, pressures, flows, and flow/membrane surface area ratios are the same for the WWTL as those specified in the ETF design, there is one significant difference, flow velocity. This is due to the relatively large diameter of the WWTL pressure vessels (4"). This results in lower WWTL flow velocities than those that will be found in the ETF system. (See Figure 3.) High flow velocities, via increased turbulence, reduce polarization concentration at the membrane surface. Therefore, the ETF RO is expected to be more efficient than the WWTL RO system. The results acquired from operating the pilot plant unit will be conservative.



28212016.3

Figure 1. Effluent Treatment Facility Reverse Osmosis Flow Diagram

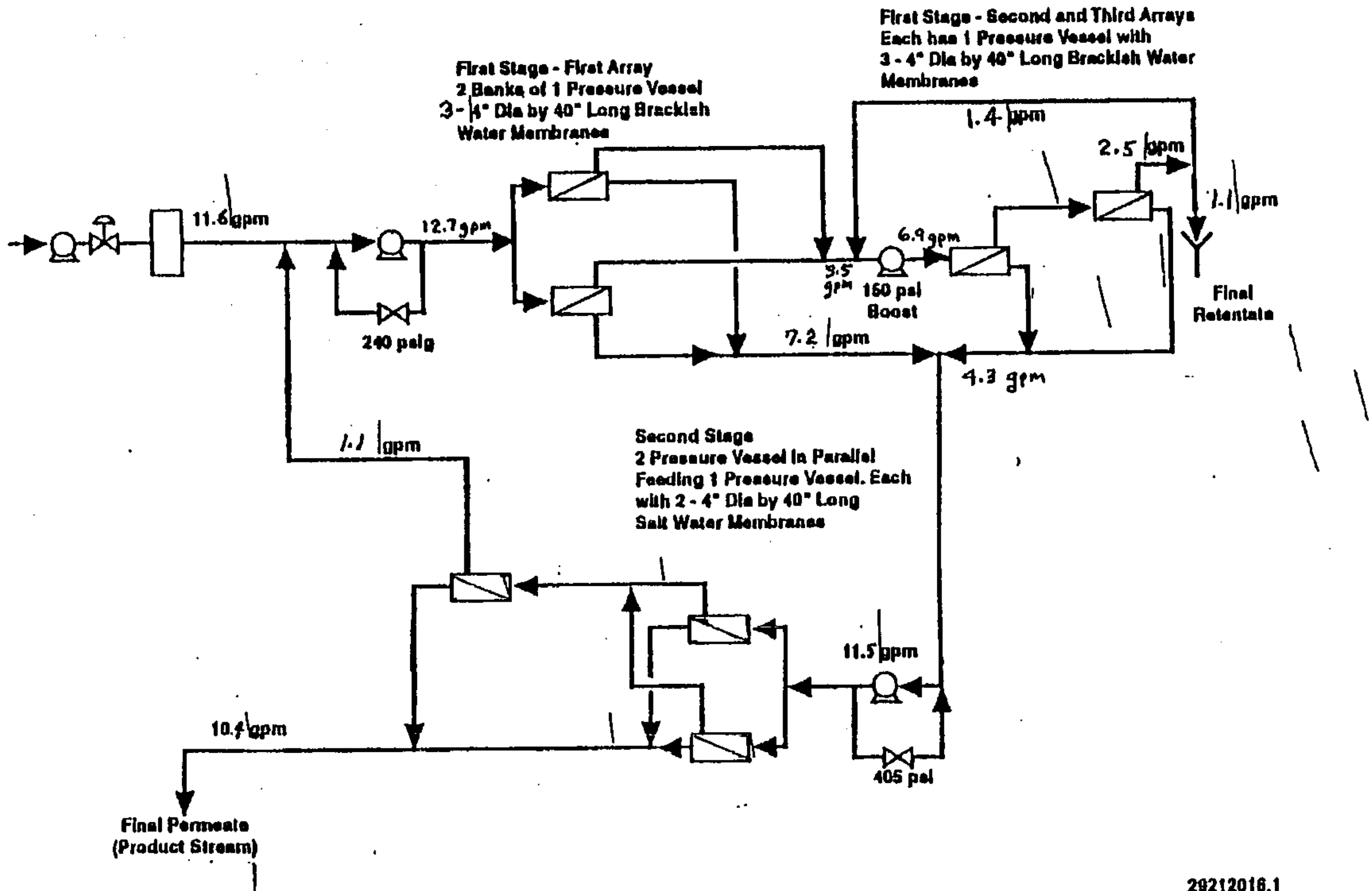


Figure 2. Pilot Plant Reverse Osmosis Flow Diagram

Page

Figure 3.

Scale Factors for Reverse Osmosis - Pilot Plant vs
Effluent Treatment Facility

A direct comparison of the pilot plant and ETF design parameters is shown in the table below. For this table "1s/1a" is an abbreviation for 1st stage/1st array, etc., and all fluxes are in gallons per square ft per day. The "feed velocity parameters" are in gallons per minute per square inch. (See sample calculations, Figure 4.)

Parameter	Pilot Plant	Effluent Treatment Facility
Feed rate, gpm	11.6	171
Membrane diameter, inches	4	8
1s/1a permeate flux	21.6	21.7
1s/2a & 3a permeate flux	12.9	13.0
2s/1a & 2a permeate flux	31.2	31.2
Feed Velocity Parameter, 1s/1a	0.51	0.94
Feed Velocity Parameter, 1s/2a	0.55	1.00
Feed Velocity Parameter, 2s/1a	0.46	0.85
Estimated overall salt rejection, %	99	99
Estimated overall water recovery, %	90	90
2nd stage retentate recycle rate, % of total feed	9.0	9.0

Figure 4

Sample Calculations

1. permeate flux, 1s/1a, ETF:

   permeate flow = 107 gpm
   membrane area/pressure vessel = 1776 square feet
   number of pressure vessels (pv) in use = 4

   permeate flux = (107 gpm)(1440 min/day)/(1776 ft2/pv x 4 pv)
   = 21.7 gal/ft2-day

2. feed velocity parameter (FVP), 1s/1a, WWTL:

   feed rate = 12.7 gpm
   pressure vessel diameter = 4 inches
   number of pressure vessels (pv) in use = 2

   $$FVP = \text{feed rate/array pressure vessel cross sectional area}$$
   $$= 12.7 \text{ gpm}/[\pi(4 \text{ inches})^2/4\ (2)]$$
   $$= 0.50 \text{ gpm/in}^2$$

3. overall salt rejection (SR), ETF:

   feed flow rate, F = 171 gpm
   feed salt concentration, C_F = 2730 ppm
   permeate flow rate, P = 154 gpm
   permeate salt concentration, C_p = 24 ppm

   $$SR = \{1-(P)(C_p)/[(F)(C_F)]\} \times 100\%$$
   $$= \{1-(154)(24)/[(171)(2730)]\} \times 100\% = 99.2\ \%$$

4. water recovery, ETF:

   feed flow rate, F = 171 gpm
   permeate flow rate, P = 154 gpm

   water recovery = P/F x 100% = 154/171 x 100% = 90.1%

containment details for all the units identified in permit condition V.A. consistent with the criteria specified in Subsection 4.1.2. These revisions to Table 4-1 of Attachment 4 of this permit shall not be considered modifications to this permit and shall be implemented in accordance with permit condition II.M.

V.D. TREATMENT UNIT MANAGEMENT

V.D.1. The Permittee shall be limited to the following treatment capacity:

V.D.1.a.i.
Units located at the 1706-KE Building shall individually be limited to 5 gallons per minute, with the exception that the UV/Oxidation unit is allowed to operate up to 25 gallons per minute in a recycle mode, but is limited to a 5 gallon per minute throughput.

V.D.1.a.ii.
Units located at the 1706-KE Building shall collectively be limited to 5000 gallons per week.

V.D.1.b.i.
This permit condition provides sufficient operational restrictions
Units located at the Liquid Effluent Retention Facility shall individually be limited to 5 gallons per minute, with the exception that the pH adjustment unit is allowed to operate up to 15 gallons per minute. ~~The units at the Liquid Effluent Retention Facility shall be allowed to operate continuously in parallel at a collective rate of up to 15 gallons per minute and shall be limited to 151,200 gallons during any calendar month.~~

V.D.1.b.ii.
Please delete.
~~Units located at the Liquid Effluent Retention Facility shall collectively be limited to 5000 gallons per week.~~
151,200 or month
① perf[illegible] leave [illegible] OR ②

V.D.2. The Permittees shall operate and monitor the treatment units as specified in Subsection 4.1.3, 4.1.5, 4.2, 4.3.3.2.1, Figures 4-1 through 4-14, 4-20 through 4-24, Appendix C, and Table 4-4 of Attachment 4 of this Permit, under permit condition V., except the following changes are hereby made to Attachment 4 of this Permit:

V.D.2.a. Table 4-4, page T4-4.3, under "UV-vsi uv/ox reactor vessel" for "high temperature" under subheadings "Control method(s)" and "Control Device" add "Temperature indicators UV-TI-1 and UV-TI-2".

OPTIONAL FORM 99 (7-90)

FAX TRANSMITTAL	# of pages ▸ 1
To STEVE SKURLA	From DAN DUNCAN
Dept./Agency WHC	Phone # (206) 553-6693
Fax #	Fax #

FAX COVER SHEET

Date: 2/19/93

Page 1 of 13 Pages (Coversheet included)

Fax Number To:	Fax Number From:
6-0306	6-2816
Name: Cliff Clark	**Name:** M. Cline
Phone Number/Location: 6-9333	**Phone Number/Location:** 6-7857
Organization: DOE/RL	**Organization:** WHC

Message

Attached responses to
RDD permit comments

A-5000-865 (01/92) WEF189

93129361755

MESSAGE CONFIRMATION

DATE:02/19/93 TIME:10:36

ID:

DATE	TIME	TX-TIME	DISTANT STATION ID	MODE	PAGES	RESULT
02/19	10:30	06'41"	509 376 0306	G3-S	014	OK

93129160756